

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
15 February 2001 (15.02.2001)

PCT

(10) International Publication Number
WO 01/10756 A1

(51) International Patent Classification⁷: B65G 49/07 (74) Agents: RUDY, William, A. et al.; Lathrop & Gage, L.C., 2345 Grand Boulevard, Suite 2800, Kansas City, MO 64108 (US).

(21) International Application Number: PCT/US00/21818

(22) International Filing Date: 10 August 2000 (10.08.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
06/148,376 11 August 1999 (11.08.1999) US

(71) Applicant: MULTILEVEL METALS, INC. [US/US]; 148 Sohier Road, Beverly, MA 01915 (US).

(72) Inventors: VANDERPOT, John, W.; 29 Pearl Road, Boxford, MA 01921 (US). POLLOCK, John, D.; 25 Kittery Avenue, Rowley, MA 01969 (US).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

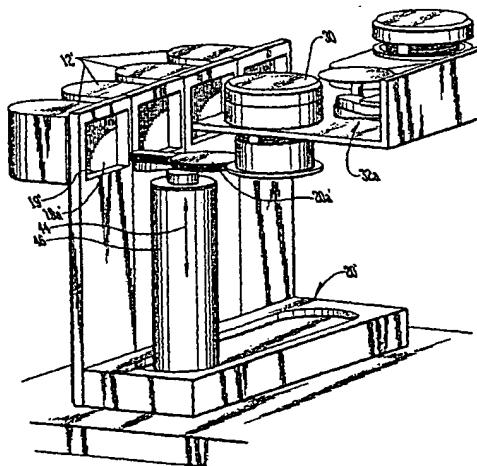
(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

— With international search report.

[Continued on next page]

(54) Title: LOAD LOCK SYSTEM FOR FOUPS



WO 01/10756 A1

(57) Abstract: The system processes one or more wafers from a FOUP (12') to an ion processing chamber. A group of wafers from the FOUP (12') is removed by a first end effector (20'a) and loaded into a load lock (30) through a lower door in an atmosphere opened position. The load lock (30) is sealed, evacuated, and an upper door is opened to a vacuum opened position. A second end effector (32a) connected to a 3-axis robot moves one of the wafers from the load lock to the ion processing chamber. A wafer alignment robot (34) can also be used. Wafers are sequentially processed from the load lock (30) to the processing chamber until complete; and then the wafers within the load lock (30) are sealed, pressurized, and moved back to the FOUP (12'). A second load lock (30), and multiple FOUP (12'), are used to increase throughput.

WO 01/10756 A1



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

LOAD LOCK SYSTEM FOR FOUPS

Related Applications

This application claims priority from U.S. Provisional Application No. 60/148,376, which is expressly incorporated herein by reference.

5 Background of the Invention

Ion beam processing systems for ion implantation of wafers are known. The prior art is familiar for example with systems that scan ion beams across target objects so as to selectively dope the target surface. U.S. Patent No. 5,028,795, entitled "Ion Implantation Apparatus" describes one such system, and is hereby incorporated by reference. In the '795 patent, two multi-pole electrostatic deflectors are used to scan the beam in two dimensions across the target surface.

The prior art is also familiar with magnetically-controlled ion beam scanning systems. U.S. Patent No. 4,922,106, entitled "Ion Beam Scanning Method and Apparatus," describes one such system, and is also incorporated by reference. In the '106 patent, a magnetic deflector with two truncated sector-shaped poles is used to control the ion beam so as to maintain a parallel beam path and a scan direction.

The prior art is further aware of systems which mechanically scan the target object in one direction, and which electrostatically or magnetically scan the beam in the other direction. In combination, therefore, such systems provide a raster scan that fully covers the target object surface. U.S. Patent No. 4,726,689, entitled "Linear Gas Bearing with Integral Vacuum Seal for use in Serial Process Ion Beam Implantation Apparatus," describes one related system, and is likewise incorporated by reference. In the '689 patent, linear gas bearings are used to provide both linear axial motion and a high differential pressure link between ambient pressure and the internal chamber vacuum.

Wafers are typically provided to ion processing systems in a FOUP (front opening unified pod), known in the art. FOUPs are heavily standardized; and so systems must accommodate interfacing to FOUPs. Certain systems process wafers at upwards of 240 wafers/hour; and so the mechanical interface and robotics between the system and the
5 FOUPs are very important.

One problem is that FOUPs are also standardized at a certain height off of the floor. Ion implantation systems, on the other hand, are relatively high, with the scanning beam approximately five feet off of the floor. Thus, a long travel distance exists between the FOUPs and the ion scanning system, resulting in a travel time that conflicts with throughput
10 goals between the FOUPs, the load lock mechanisms, and the ion scanning system.

One object of the invention is to provide a compact load lock system that increases the timing throughput between FOUPs and the ion scanning system. Other objects will be apparent in the description which follows.

Summary of the Invention

15 In one aspect, a method is provided for processing one or more wafers from a FOUP to an ion processing chamber. A group of wafers is moved from the FOUP by a first end effector and loaded into a load lock by raising the first end effector and by lowering a first load lock door of the load lock at a first atmosphere opened position. The first load lock is then sealed to its sealed position by raising the first load lock door. The load lock is then evacuated; and a second load lock door of the load lock is raised to a vacuum opened
20 position. Finally, a 3-axis robot moves one of the wafers from the load lock to the ion processing chamber.

In another aspect, the group of wafers has one to twenty five wafers.

25 In still another aspect, the FOUP is selected from one of several (typically four) FOUPs.

In yet another aspect, the step of moving one of the group of wafers to the ion processing chamber includes utilizing a wafer alignment robot.

In still another aspect, the step of loading the group of wafers into a load lock includes selecting and loading into one of a plurality of load locks.

5 In one aspect, wafers are processed sequentially from the load lock to the ion processing chamber; and then the load lock is sealed so that processed wafers are moved back to an appropriate FOUP.

In another aspect, the method includes the step of lowering the second load lock door to its sealed position by lowering the second load lock door.

10 In one aspect, the method includes the steps of reloading the wafer from the chamber to the load lock, sealing the load lock by lowering the second load lock door, repressurizing the load lock, lowering the first load lock door, removing the group of wafers from the load lock and transporting the group to the FOUP.

15 In yet another aspect, a system is provided for coupling wafers within FOUPs to an ion processing chamber. The system includes one or more FOUPs adjacent a robot track section. A vacuum robot section with one or more load locks is also adjacent the robot track section. Each of the load locks has a lower load lock door and an upper load lock door. The lower load lock door is movable between an atmosphere opened position and a sealed position. The upper load lock door is movable between a vacuum opened position and a sealed position. The track section has an ATM robot for moving one or more wafers from one of the FOUPs to a load lock through the lower load lock door in its atmosphere opened position. The system also includes a ion beam processing chamber; and the vacuum robot section has one or more 3-axis robots to move one wafer from a load lock through the upper load lock door in its vacuum opened position to the ion beam processing chamber.

Brief Description of the Drawings

FIG. 1 shows a top view of a prior art ion processing system with FOUPs.

FIG. 2 illustrates travel distance and motion between FOUPs and a processing chamber, in the prior art.

5 **FIG. 3** is a depiction of one load lock system constructed according to the invention;

FIG. 4 shows a perspective view of the system of **FIG. 3**;

FIG. 5 shows a close-up perspective view of the load locks of **FIG. 3**;

FIG. 6 shows a top view of the system of **FIG. 3**;

10 **FIG. 7** shows a perspective view of the system of **FIG. 3**, showing one operation of the robot track section in accord with the invention; **FIG. 7a** shows a close-up perspective view of the load lock of the invention; **FIG. 7b** shows a perspective close up view of the robot track section 20' with multi-layer pickup, in accord with the preferred embodiment.

FIG. 8 shows a side view, and **FIG. 9** shows a front view, of the system of **FIG. 3**.

15 **FIGs. 10-13** show operational cross-sectional views of one load lock constructed according to the invention.

Detailed Description of the Drawings

20 **FIG. 1** shows a top view of a prior art ion processing system 10 interfacing with prior art FOUPs 12. Wafers within the FOUPs 12 travel from FOUPs 12 to process chamber 14 through robot track section 20, load-locks 16 and vacuum robot section 18. Pod doors 19 interface between FOUPs 12 and robot track section 20 so that wafers can pass between

FOUPs 12 and robot track section 20. In robot track section 20, typically pressured to atmosphere, ATM robot 20a transports wafers along track 20b to move wafers between desired load locks 16 and FOUPS 12. Vacuum interfaces 21 provide atmospherically controlled valves between vacuum robot section 18 and respective load locks 16. Vacuum 5 robot section 18 has for example two vacuum robots 18a and a wafer alignment robot 18b, as known in the art. Once in processing chamber 14, a wafer is typically mounted on wafer handler 14a and implanted with ion beams.

FIG. 2 illustrates one problem in the prior art by specifically showing wafer travel distance 22 between FOUPs 12 and processing chamber 14. The difficulty with travel 10 distance 22 is that additional time is required to transport wafers along distance 22; and, in addition, travel distance 22 requires certain transport mechanisms, with longer strokes, to compensate for the height differential between FOUPs 12 and chamber 14.

FIG. 3 shows a system 23 constructed according to the invention, to overcome the difficulties in the prior art as shown in FIGS. 1 and 2. In FIG. 3, like numbers indicate 15 similar mechanisms and functionality. The main difference between FIG. 1 and FIG. 3 is that the load locks are now co-located with the vacuum robot section, thereby decreasing the volume and optimizing operations undertaken throughout the travel distance 22, FIG. 2. Specifically, wafers within FOUPs 12' travel from FOUPs 12' to process chamber 14' through robot track section 20' and vacuum robot section 32. Pod doors 19' interface 20 between FOUPs 12' and robot track section 20' so that wafers can pass between FOUPs 12' and robot track section 20'. In robot track section 20', typically pressured to atmosphere, ATM robot 20a' transports wafers along track 20b' to move wafers between desired load locks 30 and FOUPS 12. ATM robot 20a' additionally moves wafers from track 20b' to load locks 30 located within section 32. Therefore, unlike system 10, FIG. 1, vacuum robot 25 section 32 has load locks 30 integrally disposed within section 32. As described below, the vacuum interface between robot track section 20' and vacuum robot section 32 is provided through the load locks 30. Vacuum robot section 32 can for example still have vacuum robots 32a and a wafer alignment robot 34, as known in the art; but fewer movements and

shorter travel are preferred in system 23 as compared to system 10. As in FIG. 1, once in processing chamber 14', a wafer is typically mounted on wafer handler 14a' and implanted with ion beams.

FIG. 4 illustrates a perspective view of system 23; and better illustrates load locks 5 30 within vacuum robot section 32. The chamber wall 32b of section 32 is shown transparently for purposes of illustration.

FIG. 5 illustrates a perspective close-up view of load locks 30, including the 3-axis robots 32a and wafer alignment robot 34. Those skilled in the art should appreciate that wafer alignment robot 34 and robot 32a together align wafers for correct positioning within 10 process chamber 14'. FIG. 5 also shows one load lock 30a in a vacuum door opened position and one load lock 30b in an atmospheric door opened position. Load lock 30a illustratively shows wafers 42 inside. Accordingly, load locks 30 provide the pressure control interface between vacuum robot section 32 and robot track section 20'. Specifically, wafers 42 are loaded in atmosphere to the bottom 30c of load lock 30, in its atmospheric 15 door opened position, and exit through the top 30d of load lock 30, in evacuated vacuum robot section 32, in a vacuum door opened position; and vice versa. Load lock vacuum manifold 41 provides piping through which evacuation to a vacuum pump takes place; manifold 41 is also integrated with vacuum robot section 20'.

FIG. 6 show a front end top view of system 23, including robots 32a, wafer 20 alignment robot 34, load locks 30, FOUPs 12', chamber 14' and robot track section 20'.

FIG. 7 shows a perspective view of the interaction between FOUPs 12' and load locks 30, through operation of ATM robot 20a'. FIG. 7 also more clearly shows pod doors 19', typically having an opening 19a' for 300mm FOUPs 12'. ATM robot 20a' within track 25 section 20' is thus preferably a 3-axis atmospheric robot with multiple-wafer pickup capability, providing vertical "z" motion 44 via cylinder 46. FIG. 7a shows a close-up perspective view of load lock 30, including a vacuum pumping port 45 for load lock. FIG.

7b shows another close-up perspective view of load lock 30, and of robot track section 20' interfacing with FOUPs 12'. In FIG. 7b, load lock 30a is shown in its vacuum opened position and load lock 30b is shown in its atmosphere opened position. Robot track section 20' is further shown with a multi-wafer pickup 46. Load lock 30 is shown with multiple-wafer cassettes 31.

FIG. 8 shows a side view of system 23, including robot track section 20', load lock 30, robot 32a and chamber 14'. For illustration purposes, not all parts of system 23 are shown in FIG. 8:

FIG. 9 shows a front view of system 23 in one illustrative embodiment.

FIGs. 10-13 show cross-sectional views of one load lock 60, constructed according to the invention and in different operational positions. FIG. 10 for example shows load lock 60 with the following items and features:

- load lock chamber 62, load lock cover 63 and housing 65 provide the outer structure for load lock 60;
- wafer carrier 64 holds multiple wafers;
- seal plate 66 seals the top 70a of load lock 60 from the bottom 70b of load lock 60;
- differentially pumped lip seals 68 support the pressure interface of seal plate 66;
- rotary drive motor 72, linear drive motor 73, spring 76 and linear/rotary drive unit 74 provide vertical and rotational motion of wafer carrier 64 and/or load lock cover 63, selectively.

Load lock 60 is evacuated through one of several mechanisms. By way of example, a vacuum conduit 78 is connected to load lock 60 for pumping to desired pressures through

the wall 79 of vacuum robot section 32, **FIG. 3**. **FIG. 10** also shows the end effector 80 of the ATM robot 20a', **FIG. 3**. Accordingly, load lock 60 of **FIG. 10** is in the atmosphere opened position.

FIG. 11 shows load lock 60 in a different position – the vacuum opened position – 5 so that robot end effector 82 (e.g., similar to robot 32a, **FIG. 3**) can access and remove/insert a wafer carrier 64.

FIG. 12 shows load lock 60 in a pump vent condition. Wafers in carrier 64 are sealed from both end effectors 82, 80. As shown, when in the pump vent condition, carrier 64 moves upward another one-quarter inch to compress spring 76 against seal plate 66.

10 **FIG. 13** shows another position of carrier 64, indicating when seal plate 66 engages chamber 62.

The invention thus attains the objects set forth above, among those apparent from preceding description. Since certain changes may be made in the above systems and methods without departing from the scope of the invention, it is intended that all matter 15 contained in the above description or shown in the accompanying drawing be interpreted as illustrative and not in a limiting sense.

In view of the foregoing, what is claimed is:

1. A method for processing one or more wafers from a FOUP to within a processing chamber, comprising removing a group of wafers from the FOUP by a first end effector, loading the group of wafers into a load lock by raising the first end effector and by lowering a first load lock door of the load lock at a first atmosphere opened position, sealing the first load lock to its sealed position by raising the first load lock door, evacuating the load lock, raising a second load lock door of the load lock to a vacuum opened position, and transporting one of the group of wafers, via a second end effector, to the chamber.
5
2. A method of claim 1, wherein the group comprises one to twenty five wafers.
3. A method of claim 1, further comprising selecting the FOUP from one of several
10 FOUPs.
4. A method of claim 1, wherein the step of transporting one of the group further comprises utilizing a wafer alignment robot.
5. A method of claim 1, wherein the step of loading the group of wafers into a load lock comprises loading into one of a plurality of load locks.
- 15 6. A method of claim 1, further comprising transporting the one wafer from the chamber to the load lock and transporting another of the wafers from the load lock to the chamber.
7. A method of claim 1, further comprising lowering the second load lock door to its sealed position by lowering the second load lock door.
- 20 8. A method of claim 1, further comprising reloading the wafer from the chamber to the load lock, sealing the load lock by lowering the second load lock door, repressurizing the load lock, lowering the first load lock door, removing the group of wafers from the load lock and transporting the group to the FOUP.

9. A method of claim 1, wherein the step of transporting one of the group comprises using a second end effector with 3-axis robotic movement.

10. A system for coupling wafers within FOUPs to a processing chamber, comprising:

one or more FOUPs adjacent a robot track section;

5 a vacuum robot section with one or more load locks adjacent the robot track section, each of the load locks having a lower load lock door and an upper load lock door, the lower load lock door being movable between a first atmosphere opened position and a sealed position, the upper load lock door being movable between a first vacuum sealed position and a sealed position;

10 the track section having an ATM robot for moving one or more wafers from one of the FOUPs to a load lock through the lower load lock door in its atmosphere opened position;

a processing chamber; and

the vacuum robot section having one or more 3-axis robots for moving one wafer from a load lock through the upper load lock door in its vacuum opened position to the ion beam

15 processing chamber.

11. A system of claim 10, wherein the ATM robot comprises a first end effector for removing and alternatively replacing wafers from and to a FOUP.

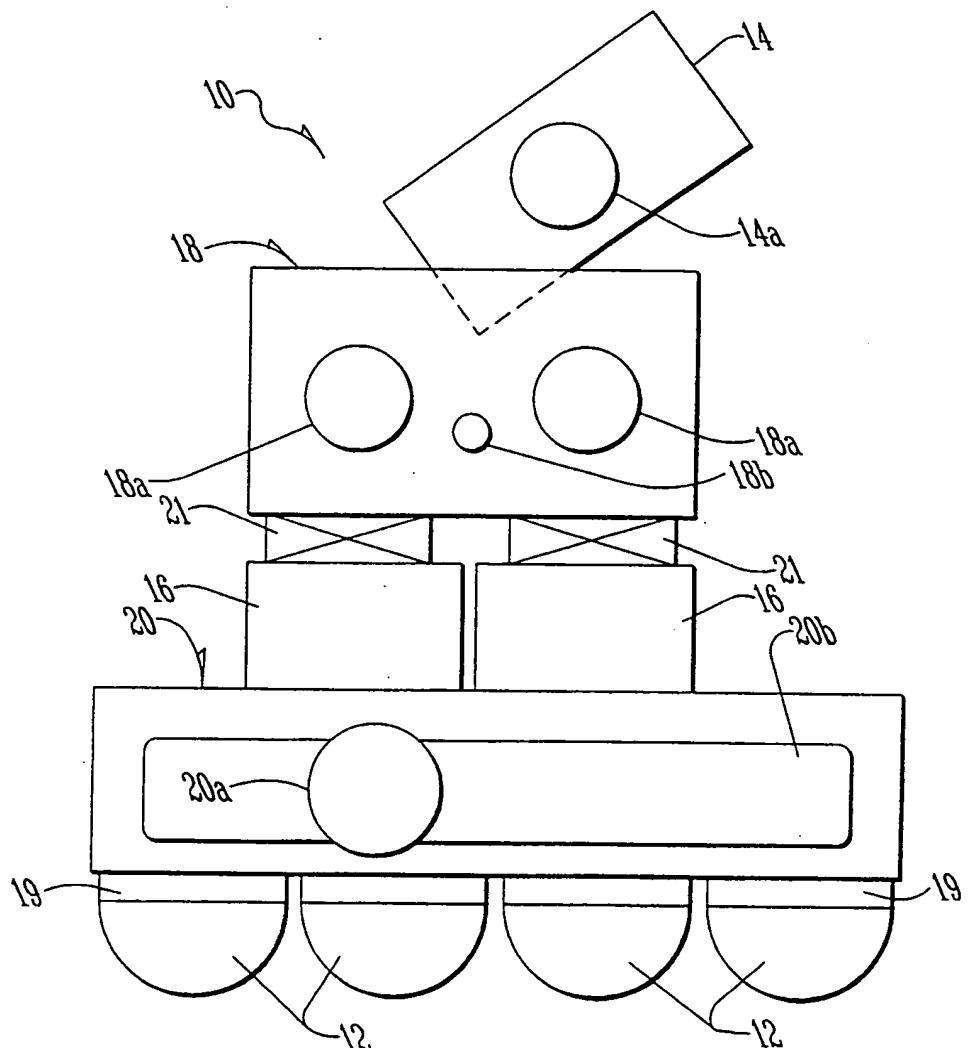
12. A system of claim 10, wherein the 3-axis robot comprises a second end effector for removing and alternatively replacing a wafer from and to a load lock.

20 13. A system of claim 10, wherein the vacuum robot section further comprises a wafer alignment robot, the 3-axis robot and the wafer alignment robot acting cooperatively to move wafers within the vacuum robot section.

14. A system of claim 10, wherein each of the FOUPs contains between about 1 and 25 wafers.

15. A load lock for an evacuated processing system, comprising a first load lock door, a second load lock door, one or more motors, and an interior chamber for containing a group
5 of wafers, each of the first and second load lock doors having a sealed position to seal the load lock so as to separately evacuate the interior chamber, the first load lock door having a atmosphere opened position so as to load wafers to and from the interior chamber, the second load lock door having a vacuum opened position so as to load wafers to and from an evacuated processing chamber, the motors moving the first load lock door between its sealed
10 position and the atmosphere opened position, selectively, the motors moving the second load lock door between its sealed position and the vacuum opened position, selectively.

1 / 14

FIG. 1
(PRIOR ART)

2 / 14

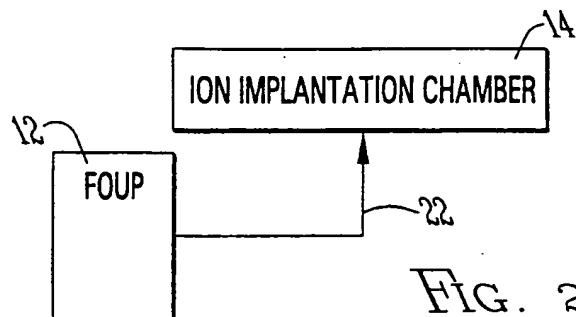
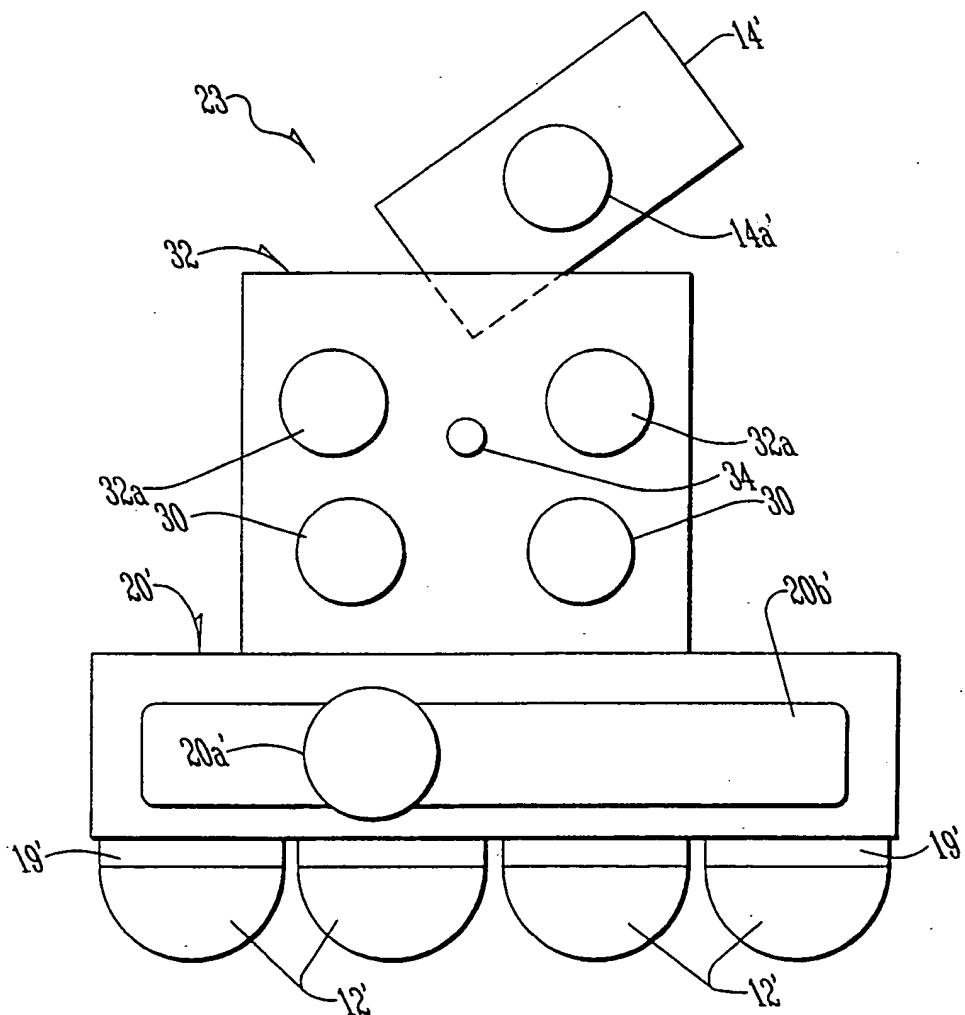
FIG. 2
(PRIOR ART)

FIG. 3

SUBSTITUTE SHEET (RULE 26)

3/14

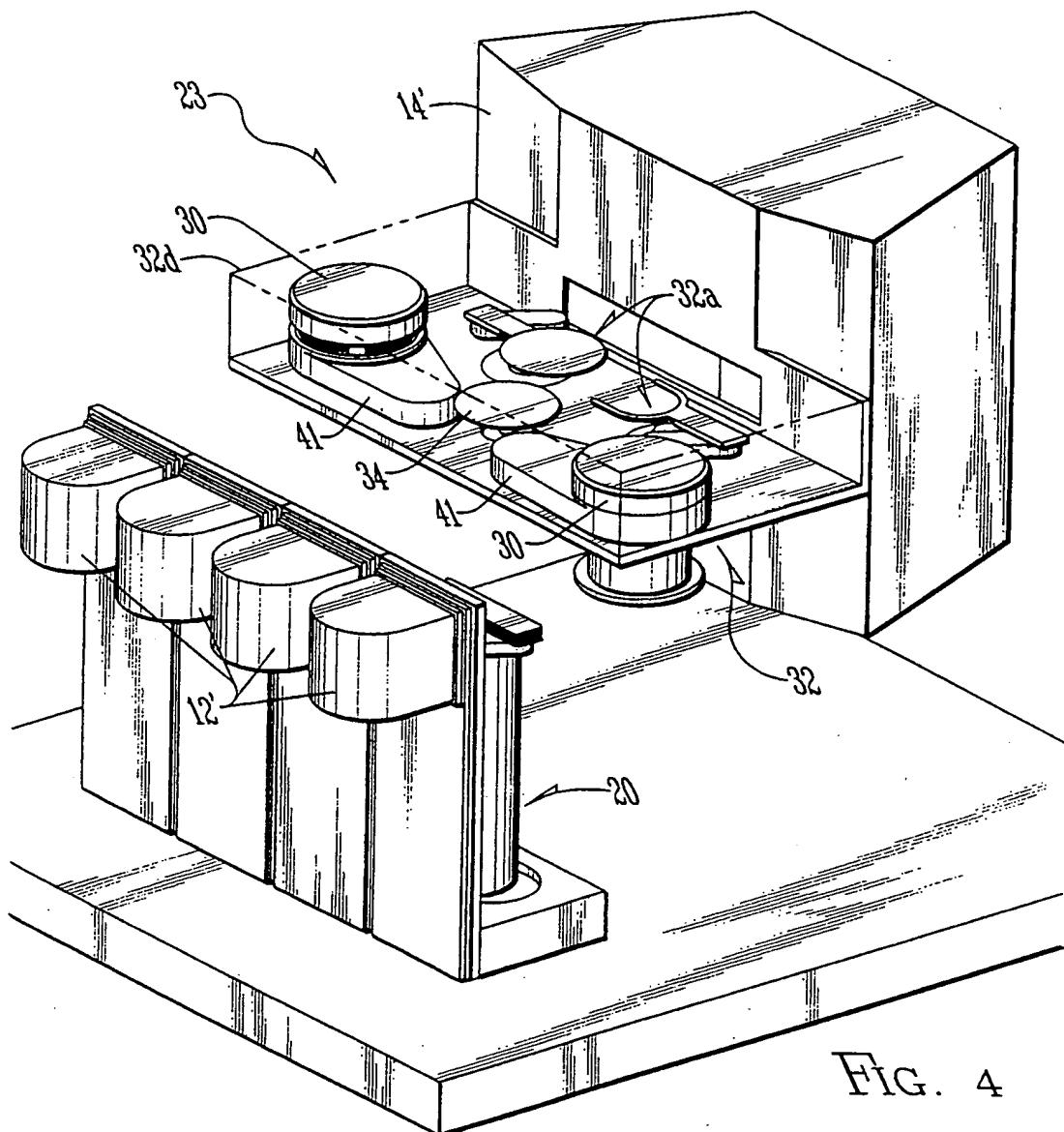


FIG. 4

4 / 14

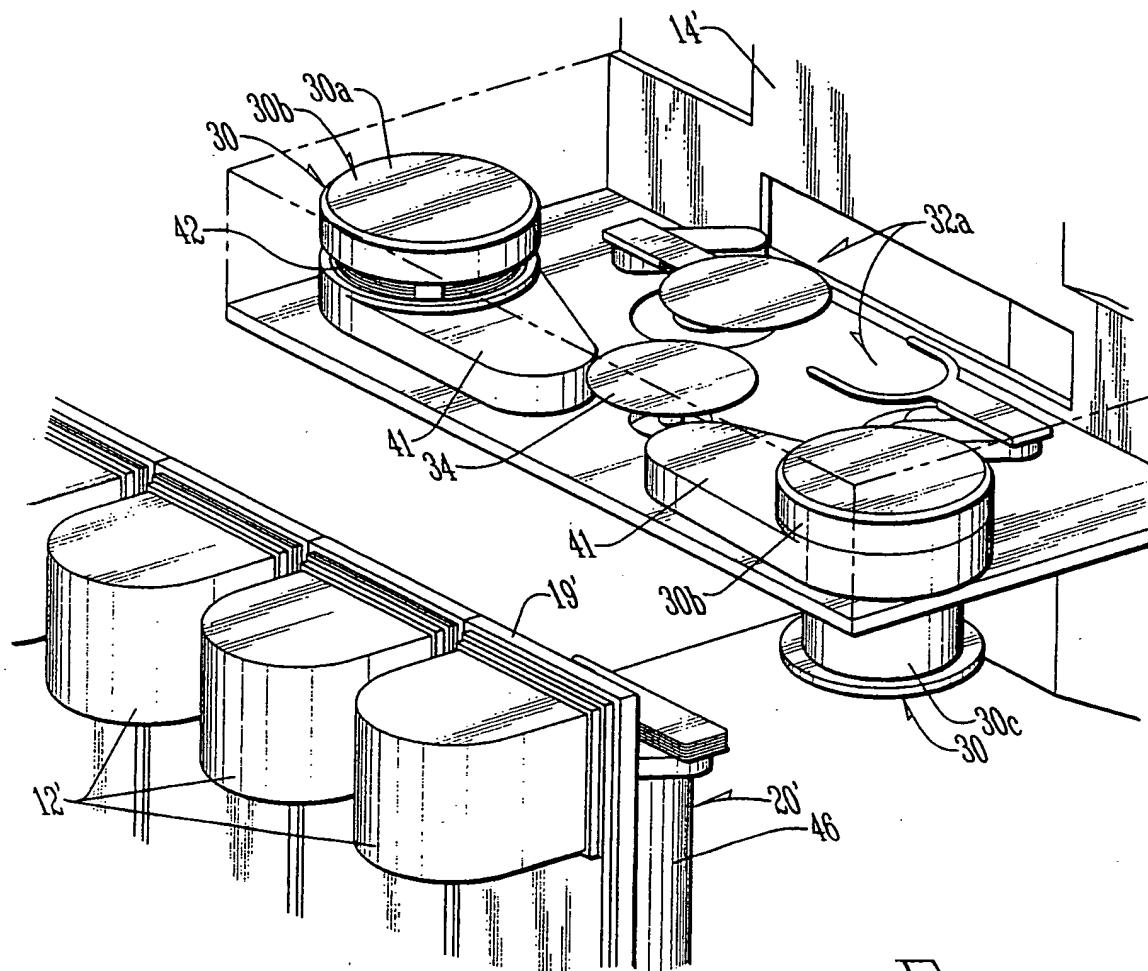


FIG. 5

5 / 14

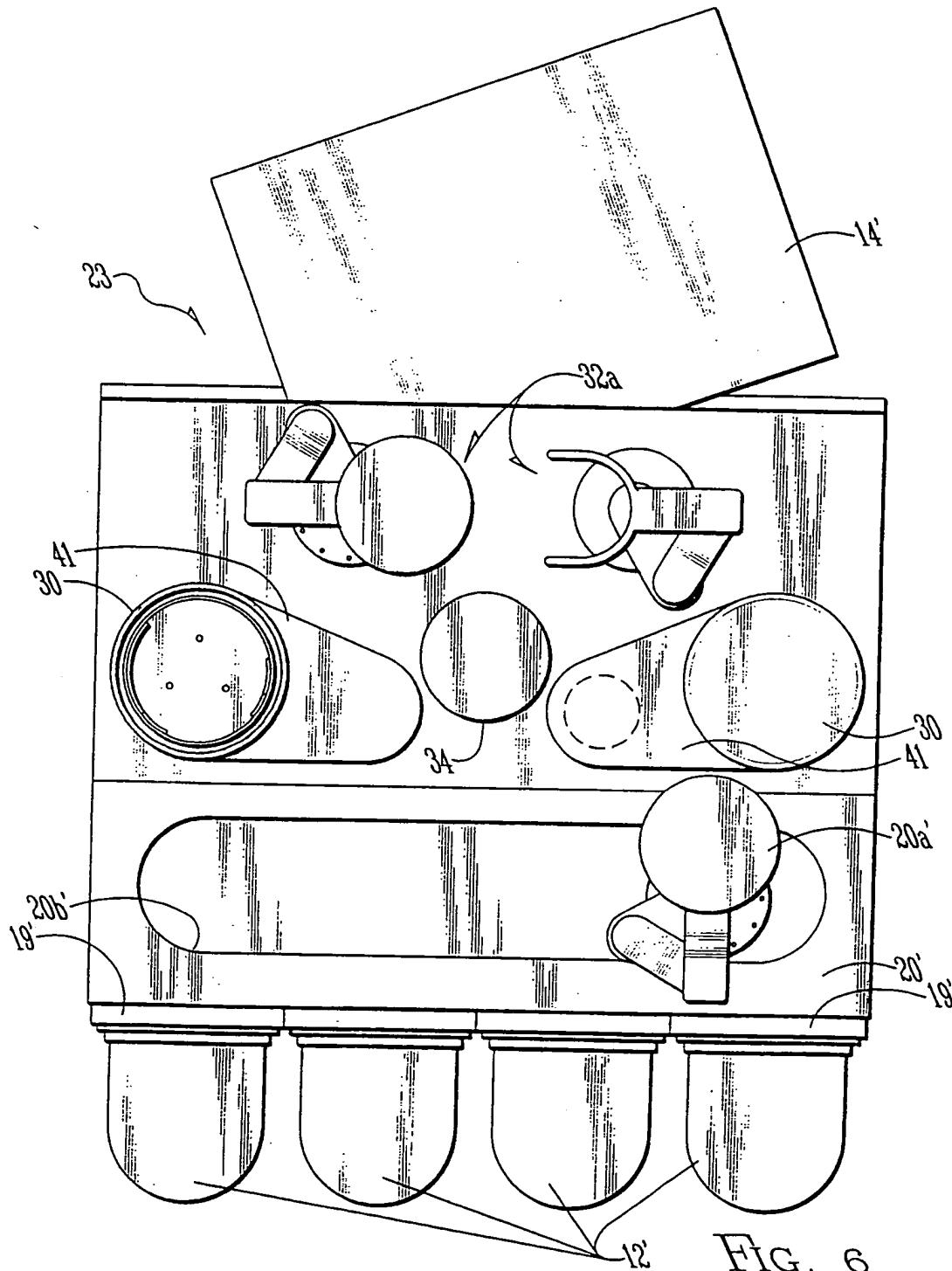


FIG. 6

6 / 14

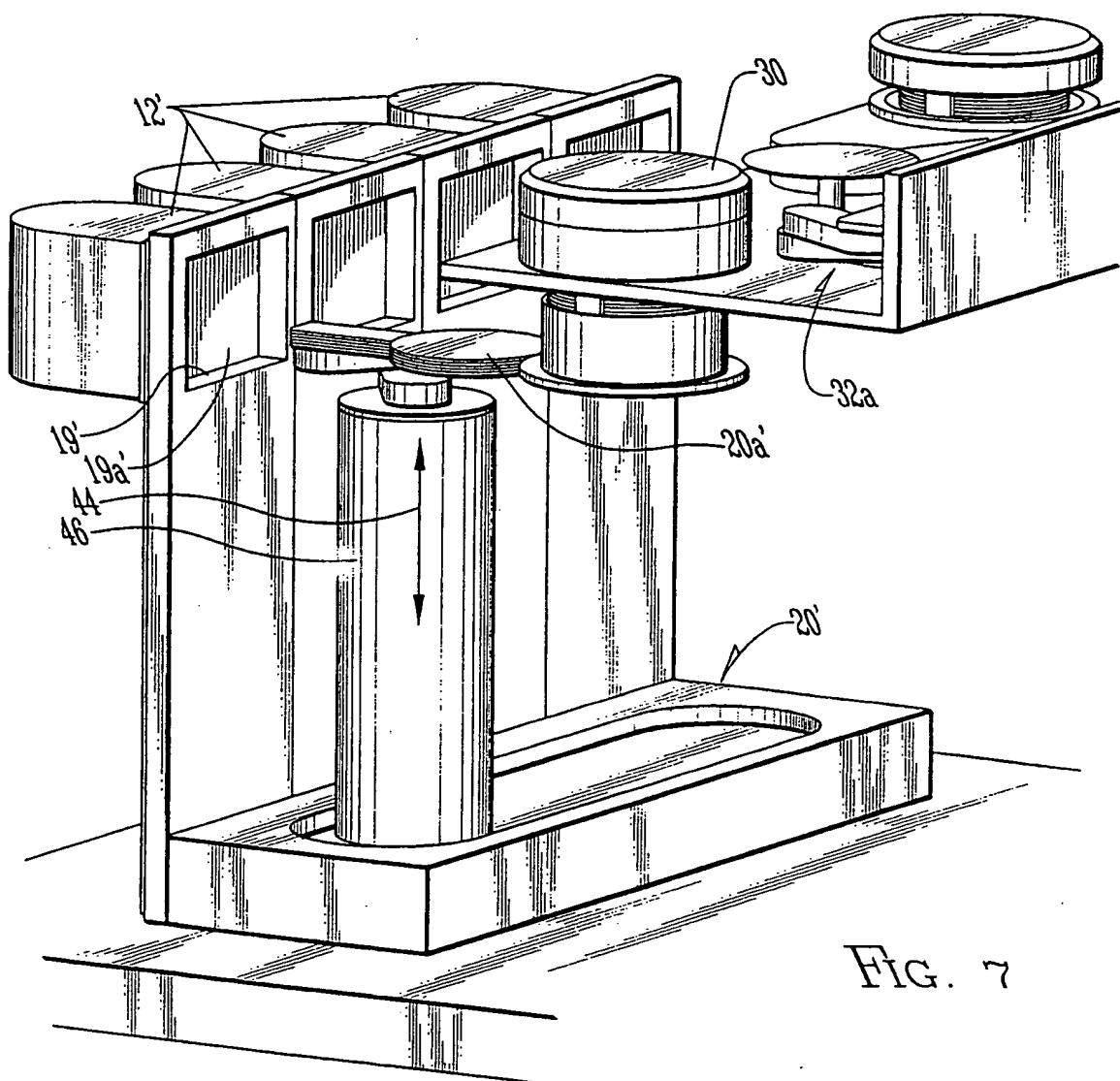
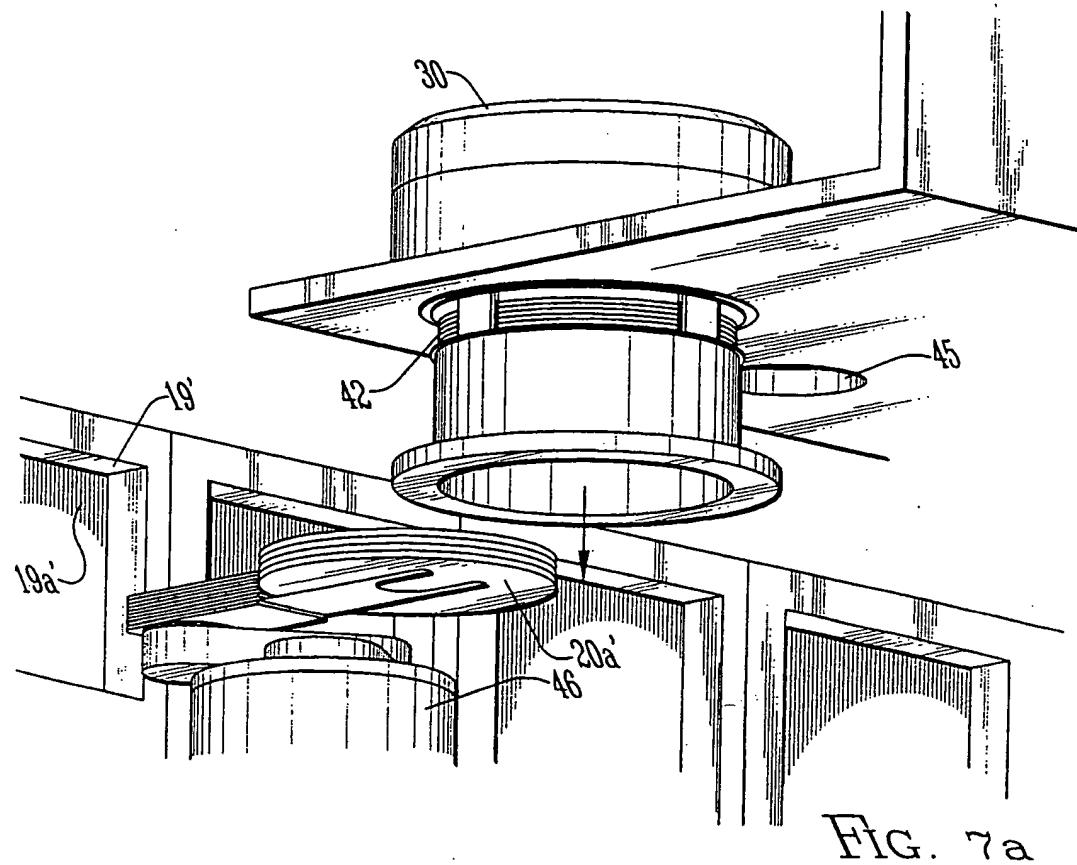


FIG. 7

7 / 14



8 / 14

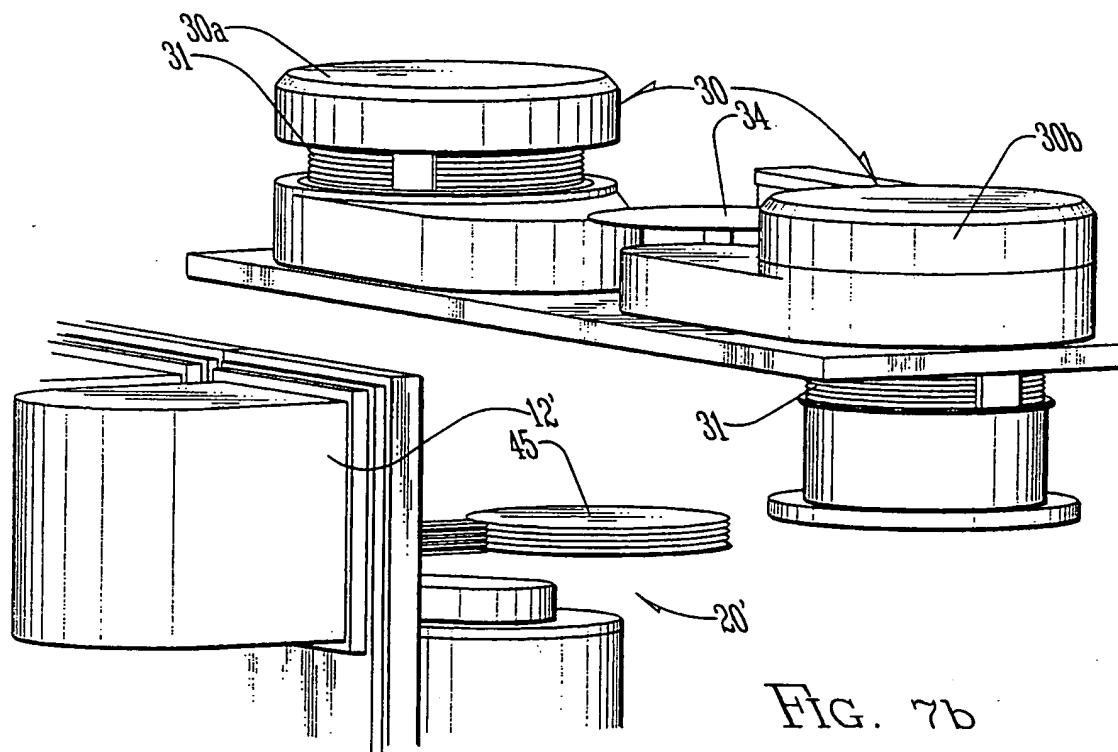


FIG. 7b

9 / 14

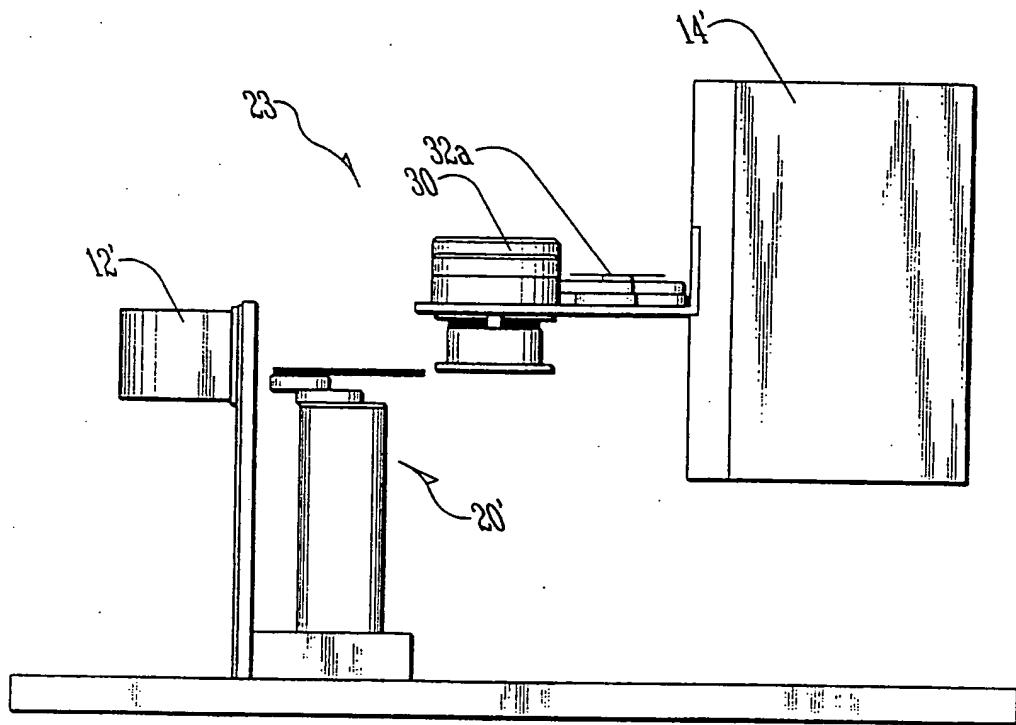


FIG. 8

10 / 14

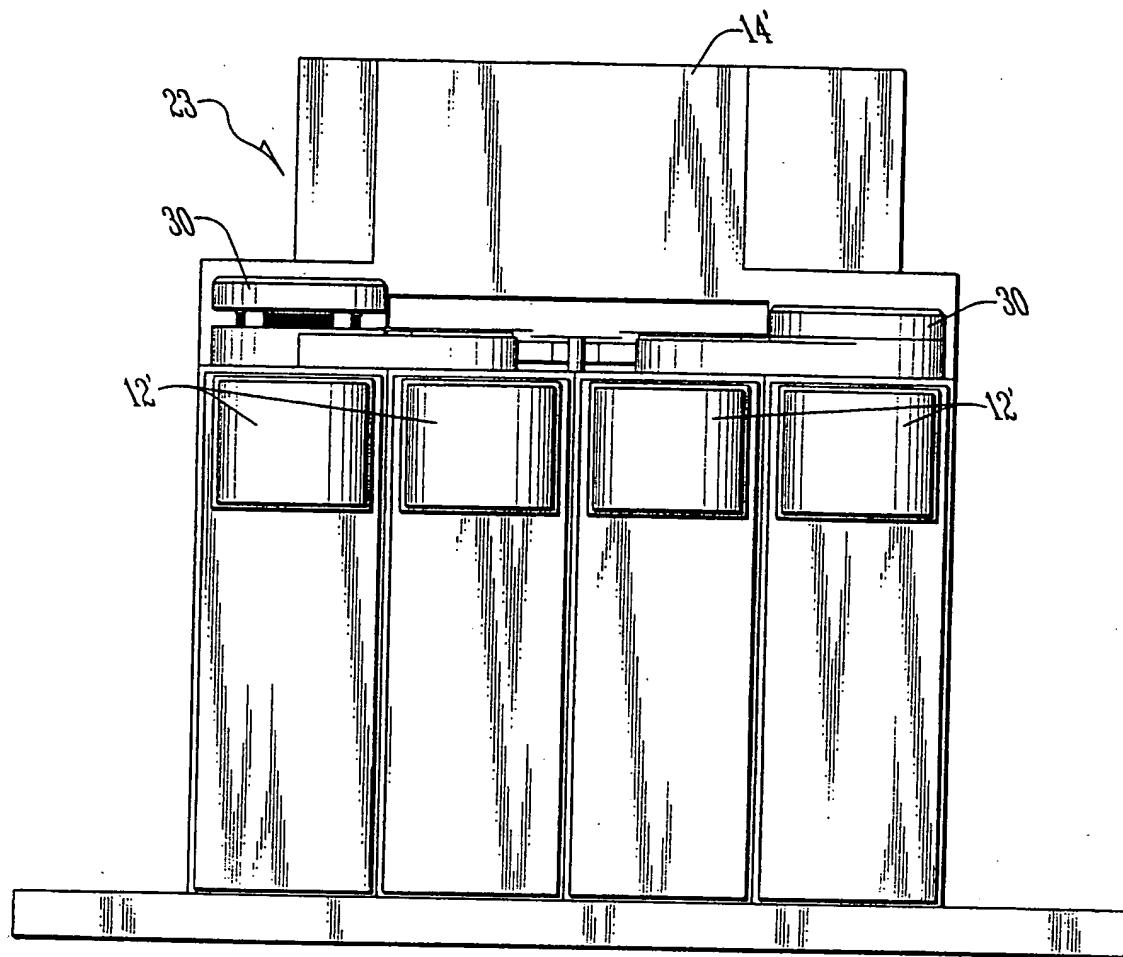
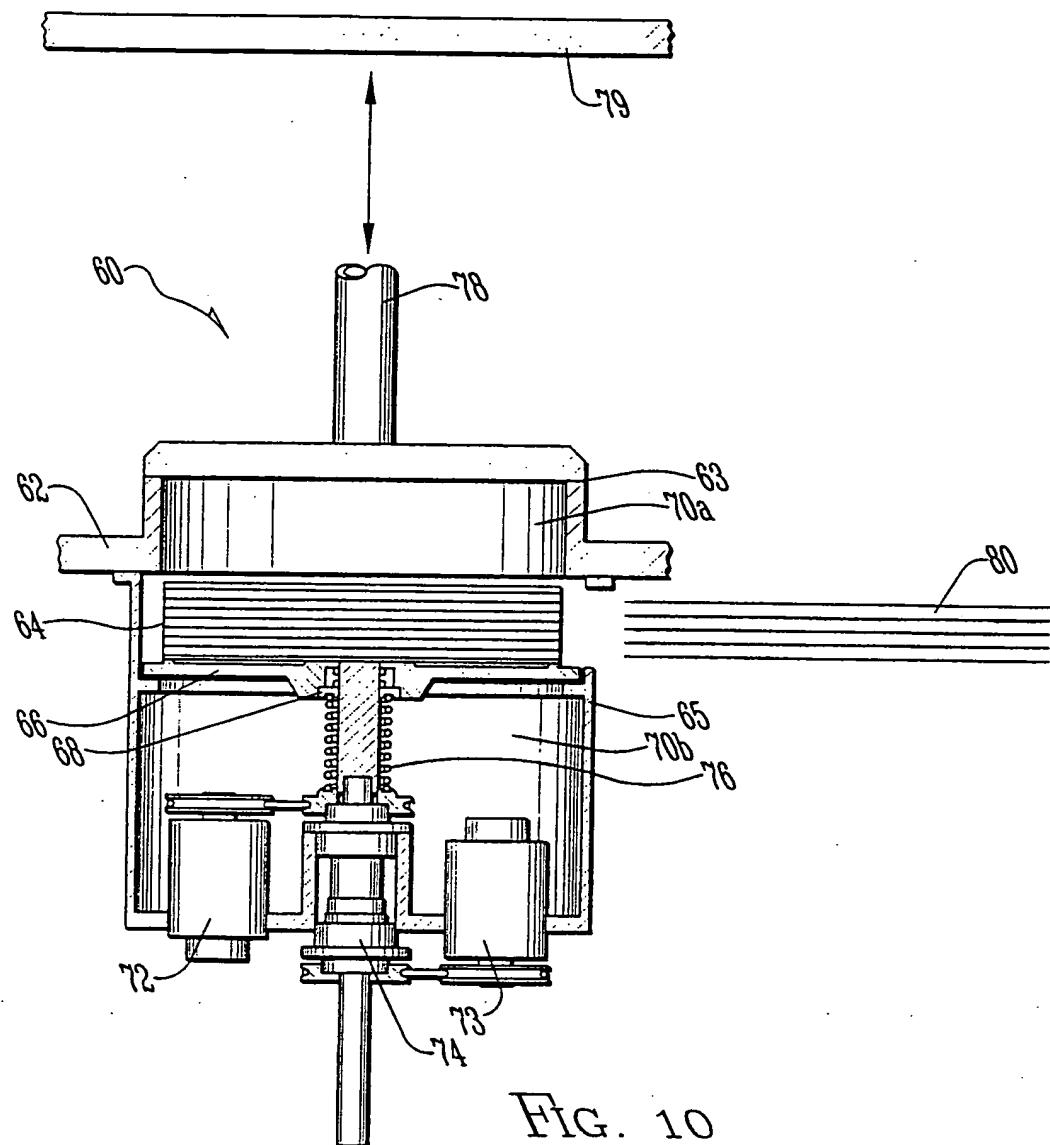


FIG. 9

11 / 14



12 / 14

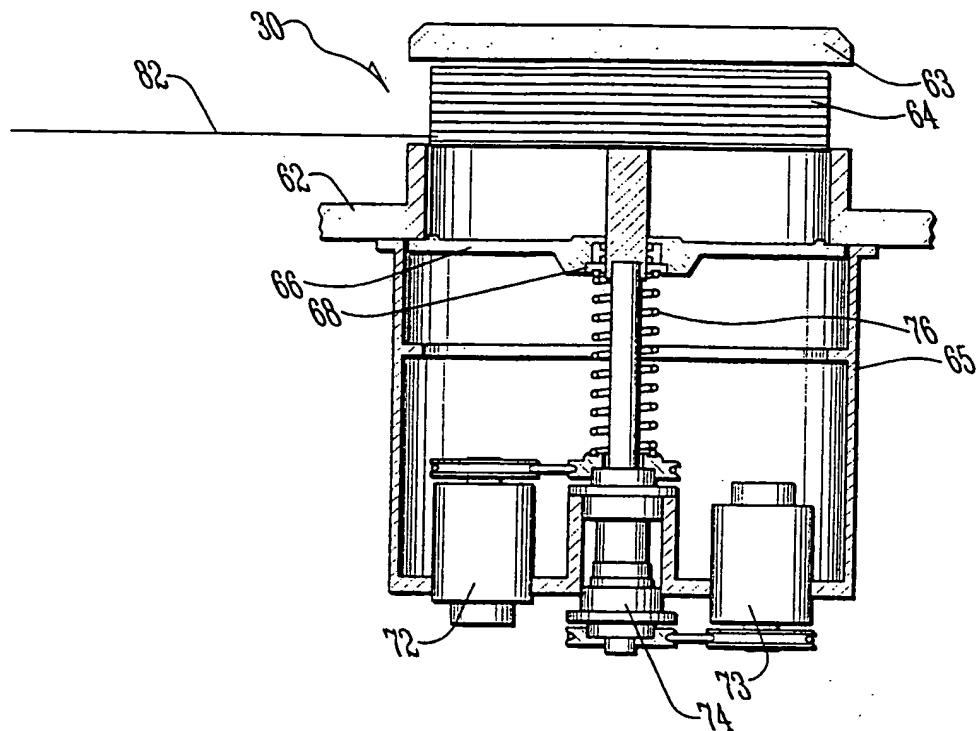


FIG. 11

13 / 14

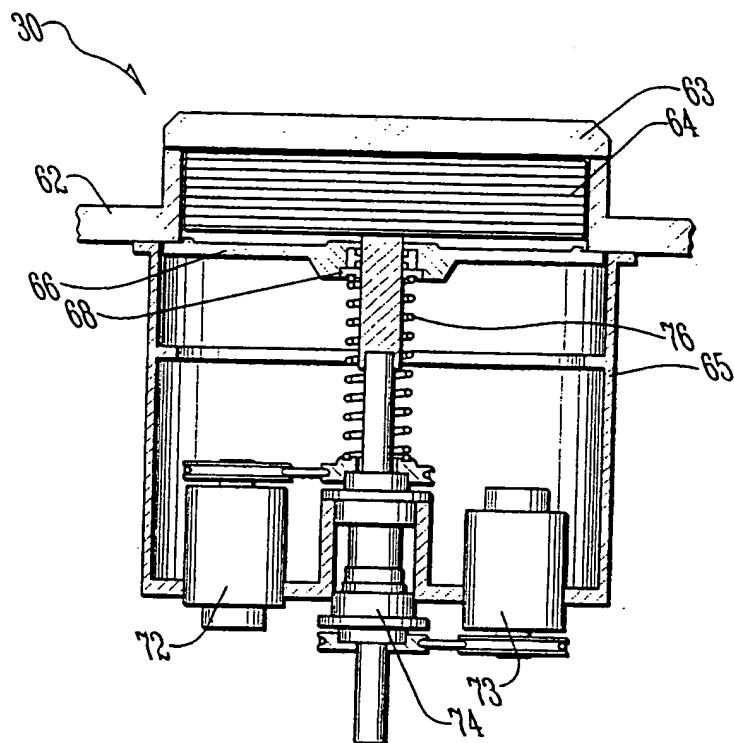


FIG. 12

14 / 14

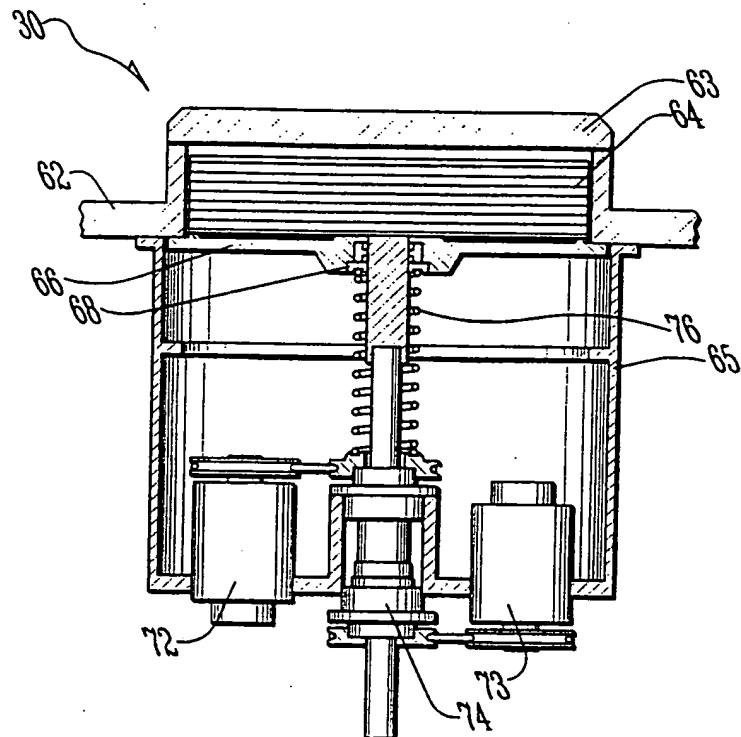


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US00/21818

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B65G 49/07
US CL :414/217;217.1;222.01;939

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 414/217;217.1;222.01;939

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WEST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,019,233 A (BLAKE, ET AL) 28 May 1991. See entire document.	1-14
Y	US 5,793,050 A (ROSE, ET AL) 11 August 1998. See element #12.	1-14
Y	JP 10-92733 A (AKUMOTO) 10 April 1998. See element # 51.	9,10-14
Y	US 4,547,247 A (WARENBACK, ET AL) 15 OCTOBER 1985. See entire document.	15
A	US 5,769,588 A (TOSHIMA, ET AL) 23 June 1998. See entire document.	1-14

Further documents are listed in the continuation of Box C. See patent family annex.

Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
E earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means		
P document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
03 OCTOBER 2000	14 NOV 2000

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer STEVEN A BRAFELD <i>Diane Smitz Jr</i> Telephone No. (703) 308-2669
---	--